REMARKS

Claims 1-2, 4-7, 9-12, 14-23 and 25 are pending in the application. Claims 1-2, 4-7, 9-12, 14-23 and 25 are rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 5,699,440 (Carmeli). Of the Claims, Claims 1, 6, 11, 16, and 21 are independent Claims. Claims 18 and 23 have been canceled. Dependent Claims 26-45 and Independent Claim 46 are newly added. The application as amended and argued herein, is believed to overcome the rejection.

The Applicants claim a camera calibration technique that requires only a blank textureless surface, for example, a blank piece of paper, and uniform illumination. The camera optical and physical shortcomings are used to extract the camera intrinsic parameters. The image of the blank textureless surface having uniform illumination is digitized. The pixel intensity drop off caused by a vignetting effect are determined from the digitized image. An intrinsic parameter of the camera other than the pixel intensity drop off is computed using the determined pixel intensity drop off. The pixel intensity drop off is also caused by an off-axis pixel projection effect and a camera tilt effect. The intrinsic parameter computed may be the focal length, aspect ratio, principal point or the skew. (*See* Applicants' specification Page 5, lines 11-13 as originally filed.) The parameters of a model are preferably computed by minimizing the difference between the digitized image and the model. One advantage of the Applicants' claimed calibration technique is that no special patterns are required. Thus, the Applicants' claimed technique recovers a camera intrinsic parameter from a single image of a blank textureless surface.

Carmeli is directed to a technique for testing the electro-optical performance of a test device in an electro-optical system. The technique provides an objective measurement of the performance of the test device. The test device is coupled to pre-calibrated devices in the electro-optical system. The performance of the electro-optical system including the test device is determined by computing electro-optical performance such as modular transfer function, contrast transfer function, grey level linearity and illumination uniformity. The electro-optical performance representative of illumination uniformity is measured based on the effect of vignetting on an output signal. (*See* Col 5, lines 52-57; Col. 6, lines 48-50; Col. 9, lines 52-61; Col. 11, line 16 and Col. 14, lines 7-18.)

The vignetting effect is observed as a reduction in illumination of image points at the edge of the image; that is, pixel intensity drop off. (*See* Applicants' Specification Page 11, lines 10-12; Page 5, lines 14-21 and Page 12, lines 14-17 as originally filed.) In contrast to the Applicants'

claimed method for calibrating a camera by "computing an intrinsic parameter of the camera other than pixel intensity drop off using the determined pixel intensity drop off", the cited prior art Carmeli merely discusses using the effect of vignetting to measure pixel intensity drop off (illumination uniformity). (*See* Col. 11, lines 10-16.) The intensity drop off measurement is the end result. There is no use of that parameter to compute another intrinsic parameter of the camera such as focal length.

Thus, Carmeli's discussion of measuring illumination uniformity based on the effect of vignetting does not teach or suggest the Applicants' claimed technique for calibrating a camera by "computing an intrinsic parameter of the camera other than pixel intensity drop off using the determined pixel intensity drop off" as claimed by the Applicants in Claim 1. Therefore, the Applicants' claimed invention is distinguished from Carmeli.

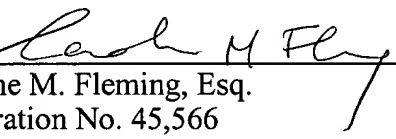
Dependent Claims 2, 4-5, 7, 9-10, 12, 14-15, 17-20, 22-23 and 25 are patentably distinct and non-obvious over the cited art at least because they are based upon independent claims shown above to be patentable, since the cited art does not contain any suggestion of "computing an intrinsic parameter of the camera other than pixel drop off using the determined drop off as claimed by the Applicants in Claim 1. Therefore, the rejections of dependent Claims 2, 4-5, 7, 9-10, 12, 14-15, 17-20, 22-23 and 25 under 35 U.S.C. §102(b) as being deemed unpatentable over U.S. Patent No. 5,699,440 (Carmeli) are improper and should be withdrawn.

CONCLUSION

In view of the above amendments and remarks, it is believed that all claims are in condition for allowance, and it is respectfully requested that the application be passed to issue. If the Examiner feels that a telephone conference would expedite prosecution of this case, the Examiner is invited to call the undersigned at (978) 341-0036.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By 

Caroline M. Fleming, Esq.
Registration No. 45,566
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
Dated: 9/9/02

MARKED UP VERSION OF AMENDMENTS

Claim Amendments Under 37 C.F.R. § 1.121(c)(1)(ii)

1. (Twice Amended) A method for calibrating a camera comprising the steps of:

digitizing an image of a blank textureless surface having a uniform illumination; [and]

from the digitized image, determining [intrinsic parameters of the camera based on] pixel intensity drop off [effects in the digitized image] caused by a vignetting effect; and

computing an intrinsic parameter of the camera other than pixel intensity drop off using the determined pixel intensity drop off.

2. (Twice Amended) [A] The method as claimed in Claim 1 wherein the pixel intensity drop off [effect] is also caused by an off-axis pixel projection effect.

4. (Amended) [A] The method as claimed in Claim 1 wherein the step of computing is dependent on a camera tilt effect.

5. (Amended) [A] The method as claimed in Claim 1 further comprising the step of computing the parameters of a model by minimizing the difference between the digitized image and the model.

6. (Twice Amended) A computer program product for calibrating a camera, the computer program product comprising a computer usable medium having computer readable code thereon, including program code which:

retrieves a digitized image of a blank textureless surface having a uniform illumination; [and]

from the digitized image, determines pixel intensity drop off caused by a vignetting effect; and

computes an intrinsic [parameters] parameter of the camera other than pixel intensity drop off based on the determined drop off [effects in the digitized image caused by a vignetting effect].

7. (Amended) The computer program product as claimed in claim 6 wherein the pixel intensity drop off [effects are] is also caused by an off-axis pixel projection effect.

9. (Amended) [A] The computer program product as claimed in claim 6 wherein the program code computes parameters based on a camera tilt effect.

10. (Amended) [A] The computer program product as claimed in claim 6 wherein the program code computes parameters of a model by minimizing difference between the digitized image and the model.

11. (Amended) A computer system comprising:

a memory system;

an I/O system connected to the memory system;

a storage device connected to the I/O system; and

a calibration routine located in the memory system responsive to a request for calibrating a camera which:

retrieves a digitized image of a blank textureless surface having a uniform illumination;[and]

from the digitized image, determines pixel intensity drop off caused by a vignetting effect; and

computes an intrinsic [parameters] parameter of the camera other than pixel intensity drop off based on the determined drop off [effects in the digitized image caused by a vignetting effect].

14. (Amended) [A] The computer system as claimed in claim 11 wherein the calibration routine computes parameters dependent on a camera tilt effect.

15. (Amended) [A] The computer system as claimed in claim 11 wherein the calibration routine computes parameters of a model stored in the storage device, by minimizing difference between the digitized image and the model.

16. (Twice Amended) An apparatus for calibrating a camera comprising:

means for digitizing an image of a blank textureless surface having a uniform illumination; [and]

means for determining pixel intensity drop off in the digitized image caused by a vignetting effect; and

means for computing an intrinsic [parameters] parameter of the camera other than pixel intensity drop off [based on] using the determined pixel intensity drop off [effects in the digitized image caused by a vignetting effect].

17. (Twice Amended) The apparatus as claimed in claim 16 wherein the pixel intensity drop off [effects are] is also caused by an off-axis pixel projection effect.

19. (Amended) [An] The apparatus as claimed in claim 16 wherein the means for computing computes parameters based on a camera tilt effect.

20. (Amended) [An] The apparatus as claimed in claim 16 wherein the means for computing further comprises means for computing parameters of a model by minimizing difference between the digitized image and the model.

21. (Twice Amended) An apparatus for calibrating a camera comprising:

a retrieval routine which retrieves a digitized image of a blank textureless surface having a uniform illumination; [and]

a routine which determines pixel intensity drop off in the digitized image caused by a vignetting effect; and

a parameter computing routine which computes an intrinsic [parameters] parameter of the camera [based on] other than the pixel intensity drop off using the determined pixel intensity drop off [effects in the digitized image caused by a vignetting effect].

25. (Amended) [A] The apparatus as claimed in claim 21 wherein the parameter computing routine further comprises a model routine which computes parameters of a model by minimizing difference between the digitized image and the model.